Milky-Way Dust from Stellar Photometry

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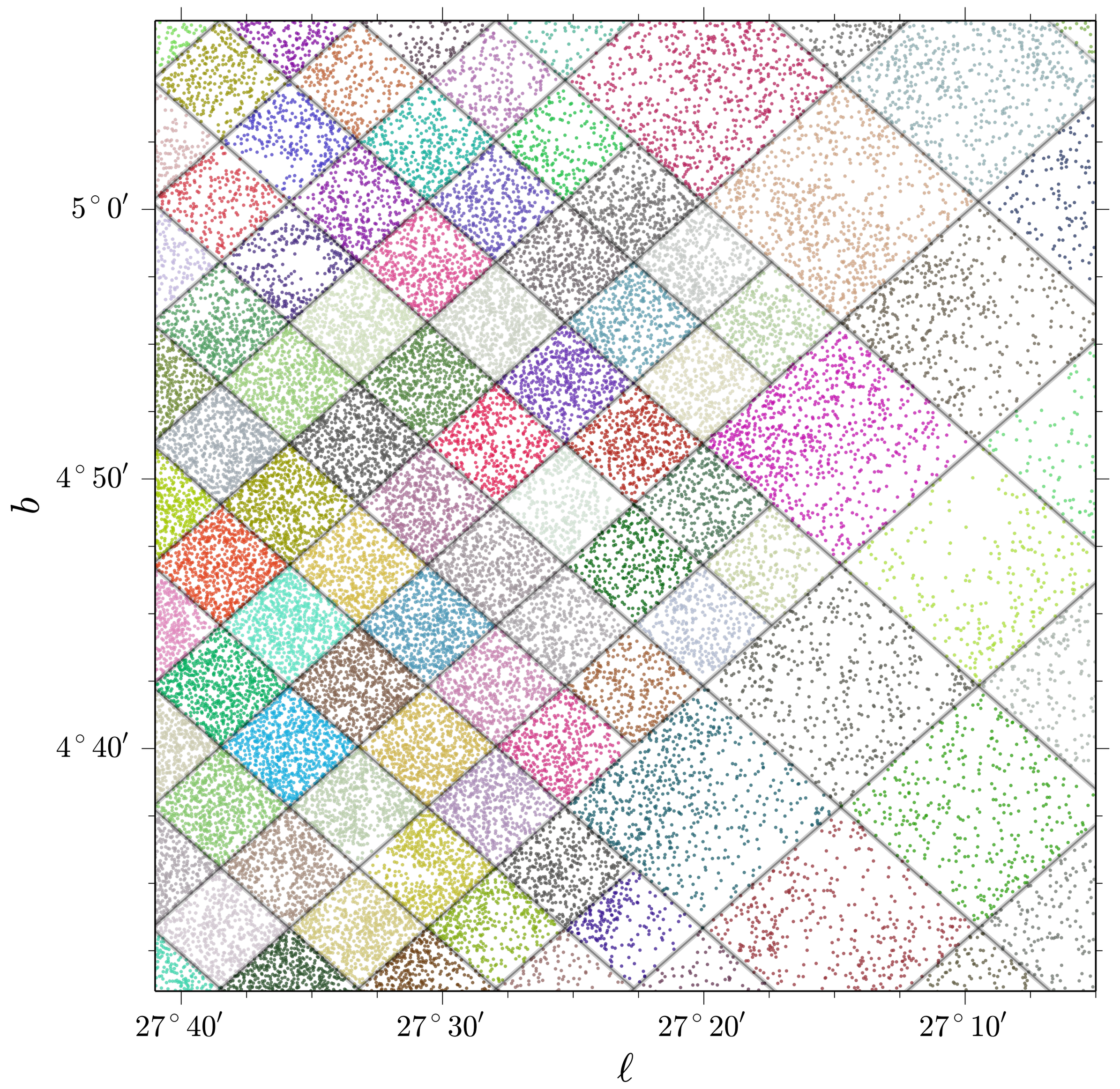
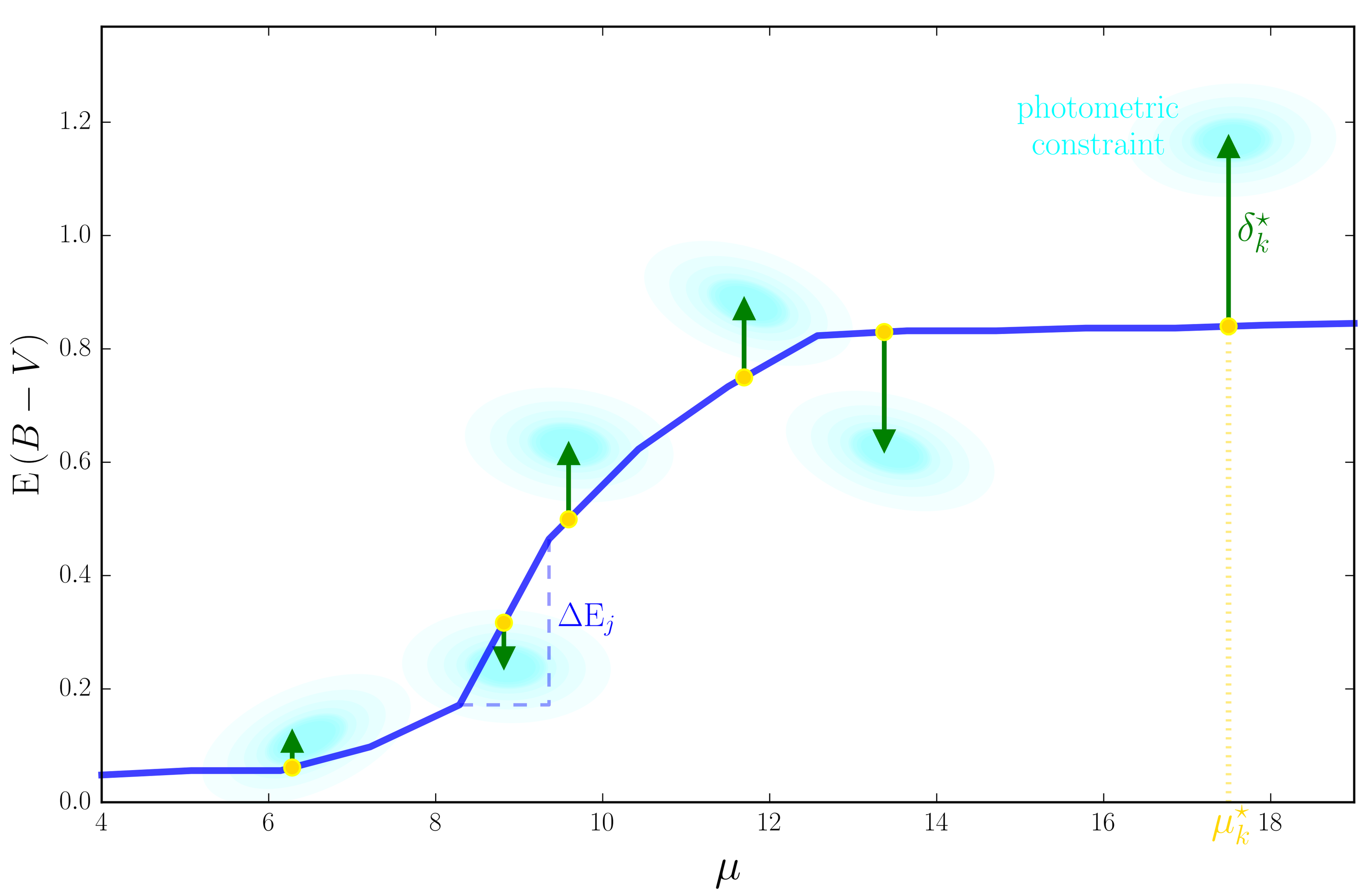
Creating the Map

Our 3D dust map is based fundamentally on stellar colors. We begin by subdividing the sky into sightlines. Within each sightline, we assume that dust column density varies little with angle, so that reddening is purely a function of distance.

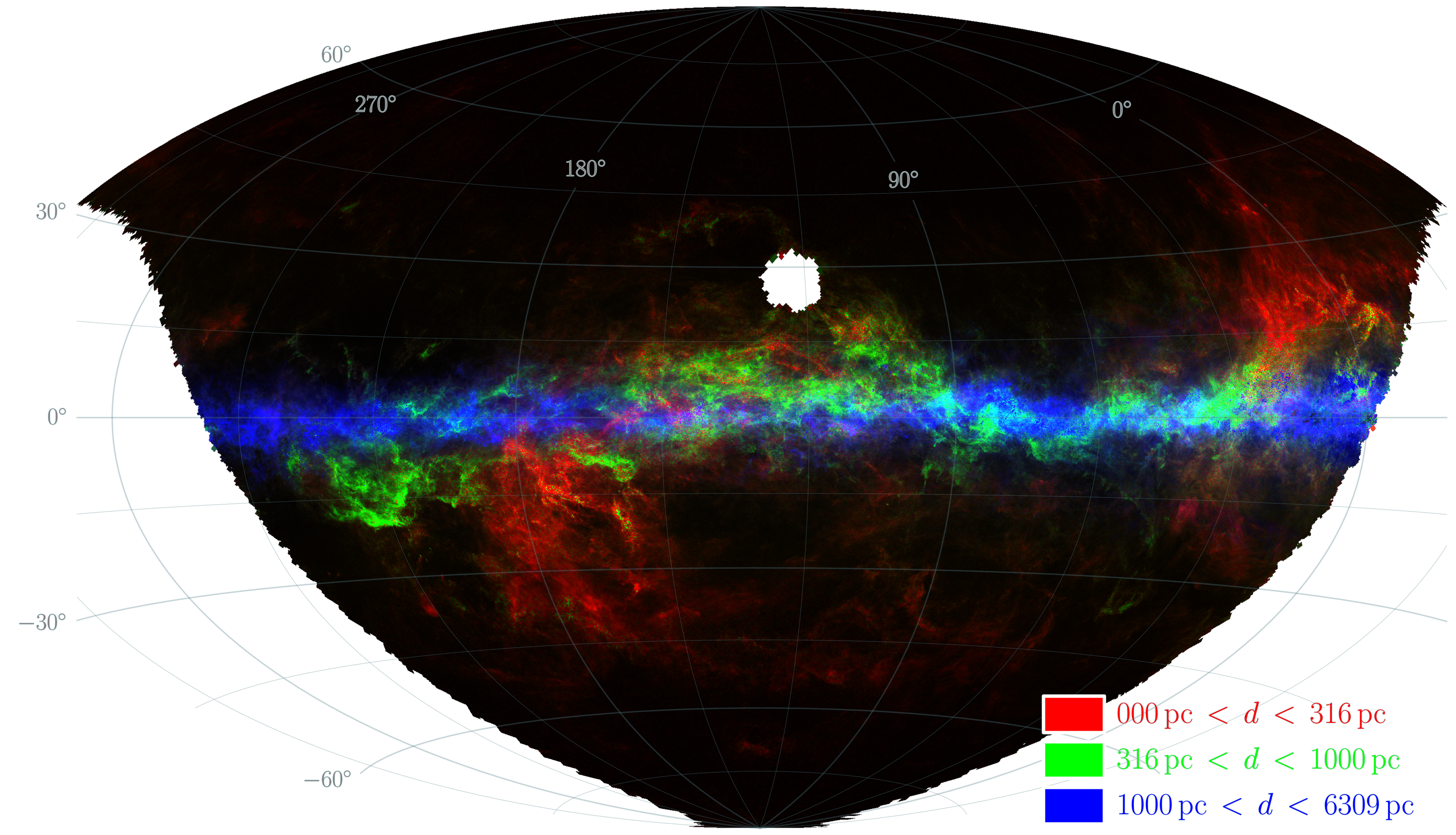


Based on stellar photometry, and a smooth model of the distribution of stars of different metallicities throughout the Galaxy, we probabilistically infer a stellar type, distance and reddening to each star. Each stellar distance and reddening puts a constraint on how reddening must increase with distance in the sightline. We use these constraints to infer how reddening increases with distance, allowing each star to be offset slightly from the "mean" distance-vs.-reddening curve in the sightline.



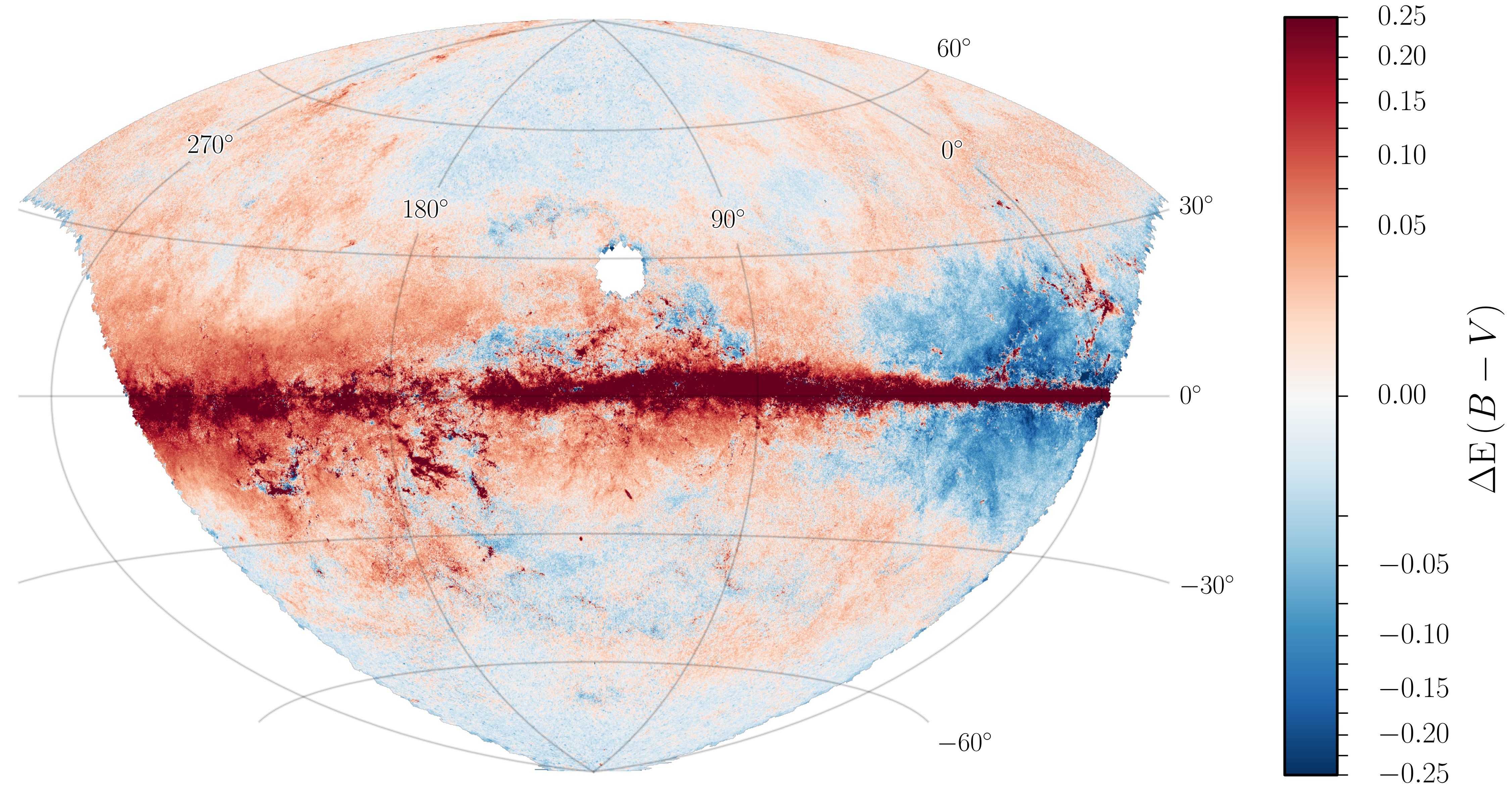
The 3D Dust Map

We apply this technique to Pan-STARRS 1 and 2MASS photometry of 800 million stars. Our resulting dust map covers the three-quarters of the sky with δ > -30°. The map traces dust on ~7' scales, with a distance resolution of ~25%.



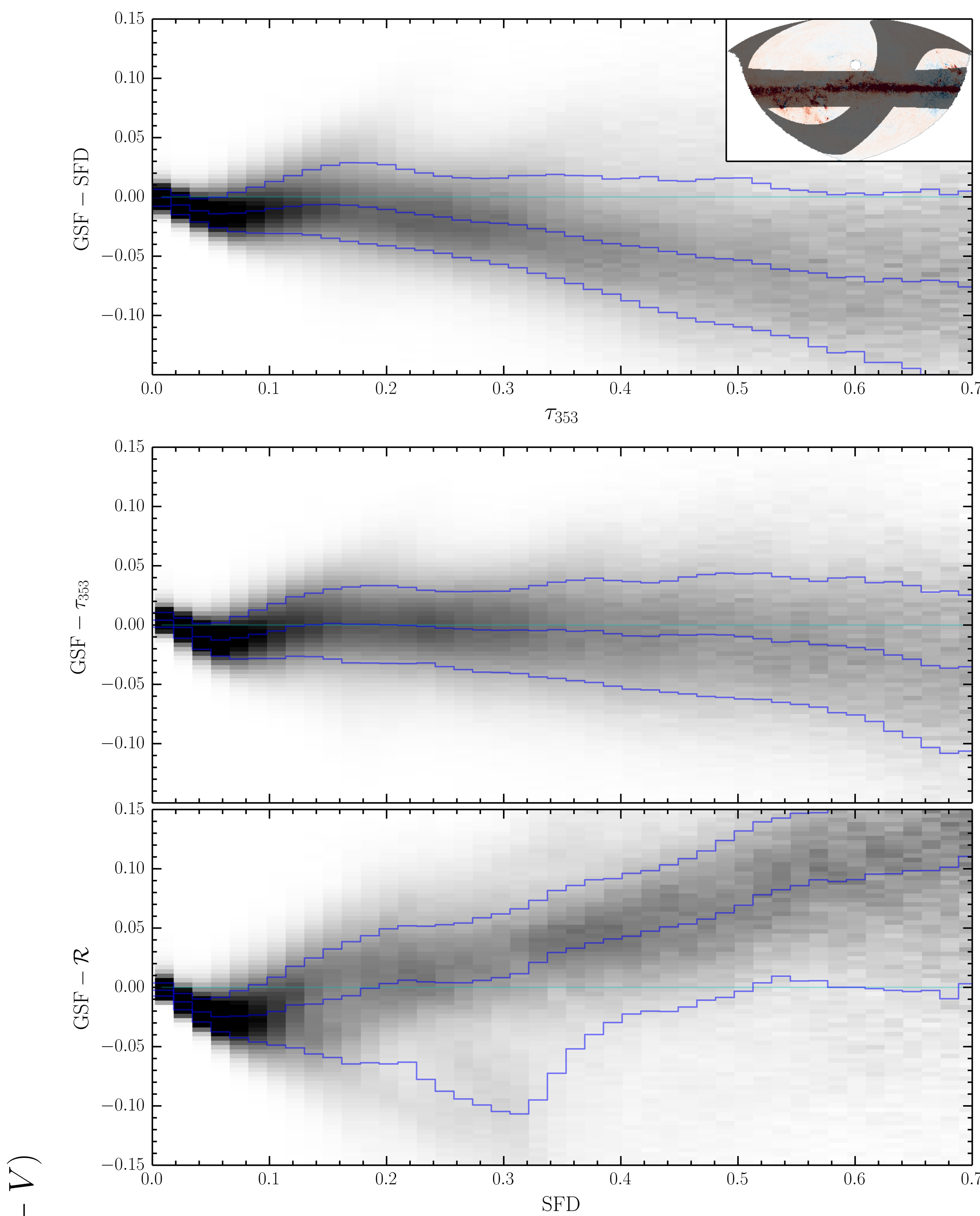
Comparison with FIR-based maps

Below, we show the residuals after subtracting our map from the Planck FIR optical-depth-based map. The Planck map is based on using FIR emission to model dust temperature, spectral index and optical depth. As our map is based on the scattering and absorption of stellar light by dust, we have very different systematics from FIR-based maps.



We agree well at high latitude. However, in the plane of the Galaxy, where we cannot see stars behind all of the dust, we do not trace the full dust column. The blue region at low Galactic longitudes is likely due to reddening law variations.

Below, we show how our map predicts reddening, compared to SFD'98 and the two Planck reddening maps, based on optical depth at 353 GHz, τ_{353}, and radiance, $\mathscr{R}$. We exclude the Galactic plane and the ecliptic.



Our map agrees best with the Planck τ_{353} map. At reddenings below ~0.1 mag in E(B-V), we predict slightly less dust. This might be caused by our prior on the distribution of dust, or by inaccuracies in our reddening vector.

Open Question:

We currently determine dust reddening along each sightline separately. How can the inclusion of priors that dust density is correlated in nearby volume elements improve our model of Galactic dust reddening?